INCH-POUND

MIL-PRF-51191E(EA)
12 June 1997
SUPERSEDING
MIL-H-51191D(EA)
1 May 1989

PERFORMANCE SPECIFICATION

HEATER, AIR, ELECTRICAL, FILTER UNIT, M3

Reactivated for new design after 12 June 1997

This specification is approved for use by the U.S. Army Chemical and Biological Defense Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers electric air heaters that provide for heating air supplied from Gas-Particulate Filter Units (GPFUs) to military personnel who wear Nuclear-Biological-Chemical (NBC) protective masks during cold weather operations.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to insure the completeness of this list, document users are cautioned that they must

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Technical Director, U.S. Army Edgewood Research, Development and Engineering Center, ATTN: SCBRD-ENE-S, Aberdeen Proving Ground, MD 21010-5423 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 4240

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

ATTACH 005

meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government Documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

DEPARTMENT OF DEFENSE

MS27142 – Connector, Plug, Electric– Pin Contact
MS27144 – Connector, Plug, Electrical– Socket Contact

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111–5094).

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DRAWINGS

ERDEC E5–19–1782 – Heater, Air, Electric, Filter Unit, M3

(Copies of this drawing are available from U.S. Army Edgewood, Research, Development and Engineering Center, SCBRD–ENE–S, Bldg E5027, APG, MD 21010–5423.

ARDEC 12910415 – Guard Assembly

(Copies of this drawing are available from U.S. Army Armament, Research, Development and Engineering Center, AMSTA–AR–EDE–S, Bldg 12, Picatinny Arsenal, NJ 07806–5000.)

2.3 Non–Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation.

Unless otherwise specified, the issues of documents not listed in the DoDISS are the issue of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1 – Unified Inch Screw Threads
ASME B1.2 – Gages and Gaging for Unified Inch Screw Threads
ASME B1.3M – Screw Thread Gaging Systems for Dimensional Acceptability

(Application for copies should be addressed to ASME, 345 E. 47th Street, New York, New York 10017.)

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA Standard 210 – Laboratory Methods of Testing Fans for Rating Purposes.

(Application for copies should be addressed to Air Movement and Control Association, Inc., 30 West University Drive, Arlington Heights, IL 60004–1893.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.2.

3.2 Maximum critical dimensions. The size of the air heater shall not exceed the following critical dimensions: The maximum length (distance between furthest inlet port location and furthest outlet port location) shall be no greater than 7.32 inches. The distance between the bottom of the mounting bracket (base plate) and the highest point on the controller housing (excluding the control knob) shall be no greater than 5.95 inches when the center axis of the controller is oriented perpendicular to the mounting bracket. Compliance with respect to critical dimensions shall be verified by 4.2.2.1. The controller shall not exceed a "footprint" of 2.78 x 3.70 inches, whereby the 2.78 inches is parallel to the longitudinal axis of the heater to allow necessary clearance for hose connections. A "footprint" is defined as the maximum length and width of the controller in any plane parallel to the heater base when the the con-

troller is upright relative to the base plate.

3.3 Compatibility with interfacing parts. In addition to the requirements in 3.2, the following requirements shall be met to insure compatibility of the air heater with the vehicle and its Gas Particulate Filter Unit (GPFU) system. The degree of movement, orientation and number of the air inlet and outlet ports shall be equivalent to those on Drawing E5-19-1782 in form, fit and function. Two threaded plugs, which are form, fit, and function equivalent to those on Drawing E5-19-1782, shall be installed in the side inlet and outlet ports. (Additional plugs may be required by solicitation or special packaging instruction.) Female screw threads in the inlet and outlet ports of the heater and those in the heater for the attachment of the controller to the heater shall conform to ASME B1.1 and be compatible in form, fit, and function to threads defined for the inlet and outlet ports and in Detail B of Drawing E5-19-1782, respectively. The cable connectors on the air heater shall be interoperable and interchangable with those shown on Drawing E5-19-1782 and in MS27142 and MS27144. The female and male connectors shall remain firmly attached except when normal hand force is used to separate them. The hole size and pattern in the mounting bracket of the heater shall conform to Detail C of Drawing E5-19-1782. The heater with controller shall have the capability to be mounted in the guard assembly (part no. 12910415) without interference. Compatibility with interfacing parts shall be verified by examination and functional checks (see 4.2.2.1).

3.4 Controller operating features. The controller shall be capable of being removed from the heater and remotely mounted inside the vehicle on a mounting that has the same threaded hole pattern as is described by Detail B of Drawing E5-19-1782. The controller shall enable the operator to change the air stream temperature over a continuous range via a temperature control knob. When the control knob is turned fully counterclockwise, no heat shall be supplied to the air stream. The controller assembly shall be totally enclosed and watertight with all electrical control circuitry (relays, switches, solid state electronics, etc.) sealed inside. The center line of the controller shall be capable of being moved at least 45 degrees in either direction (clockwise or counter-clockwise) to the vertical plane which runs through the longitudinal axis and is perpendicular to the mounting bracket. Above features of controllers shall be verified by 4.2.2.1.

3.5 Performance.

3.5.1 Heating capability and power consumption. *The heater, when conditioned and operated as specified in 4.3.6.1(a),* shall be capable of receiving 4.5 cubic feet per minute (cfm) of air, minimum, (corrected to standard conditions as defined in AMCA Standard 210) at its inlet at a temperature of $0 \pm 4°F$ and discharging this air at its outlet at a minimum temperature of 120°F within 15 minutes after starting heater set to its maximum output level without consuming more than 250 watts of power.

3.5.2 Resistance to airflow. *With the heater at ambient room temperature, the resistance*

to airflow shall not exceed a differential pressure of 0.10 inches of water when tested as specified in 4.3.6.1(b).

3.5.3 Operability with thermostatic control. The heater shall operate in a room temperature environment of 70°F and be capable of producing a regulated outlet air temperature of 120±4°F within 10 minutes of operation for all test conditions specified in 4.3.6.1(c) and shall maintain this temperature for a period of not less than 5 minutes without adjustment of the controller.

3.5.4 Case surface temperature. While the heater is operating as specified in 4.3.6.1(c), the case temperature shall not exceed 126°F.

3.6 Electromagnetic emissions. The heater shall not produce electromagnetic emissions of such magnitude that mission essential communications equipment and electronic systems are adversely effected. Measured electromagnetic emission levels shall be less than or equal to the maximum levels in table II and figures 1 through 5 in 4.2.2.2 for the specified frequency range. Electromagnetic emissions having a duration not exceeding 1 second, and recurring not more than once in 3 minutes, are exempt.

3.7 Leakage. Air leakage shall be not greater than 1.00 cubic inches (16.4 cubic centimeters) per minute when the filter is internally pressurized to at least 12 inches (30.5 centimeters) of water as specified in 4.3.6.2.

3.8 Minimum operating life. The heater, when operating under conditions specified in 4.3.6.3, shall maintain the outlet temperature of 120± 4°F for a continuous period of at least 250 hours.

3.9 Resistance to environmental conditions. The heater shall pass the requirements of 3.5.3 when the input voltage is 27.5 vdc after exposure to the environmental conditions of temperature shock, humidity, mechanical shock, vibration, salt fog, and fungus when tested as specified in table I.

3.10 Cold temperature operation. When the heater is operating in a temperature environment of −45°F as specified in 4.3.6.4, it shall be capable of producing a regulated outlet air temperature of 70±4°F within 15 minutes of operation and shall maintain this temperature for a period of not less than 5 minutes without adjustment of the controller.

3.11 Compatibility with vehicle electrical system. The heater shall be capable of withstanding normal vehicular voltage surges and spikes such as the following. The heater with controller shall be capable of withstanding a surge voltage of 39 volts for 10 seconds and recover within 0.015 second when tested according to 4.3.6.5. The heater with controller shall meet the requirements in 3.5 after withstanding a spike voltage of 250 volts for 0.015 milliseconds.

3.12 Operability during movement. The heater shall meet the requirements in 3.5 when the air inlet and outlet ports are rotated as specified in 4.3.6.6. The heater shall not malfunction due to opening or shorting of internal wiring.

3.13 Identification and markings. Each heater shall contain the following indentification information: "Heater, air, electric, filter unit, M3"; 27.5 vdc rating, nominal maximum power rating in watts at the specified 27.5 vdc input voltage; lot number, model and/or serial number, and contract number. Electrical leads between the controller and heater shall be marked with permanent markings on both sides of the electrical connectors to ensure that leads are identifiable for correct reconnection. The inlet and outlet airflow ports shall be clearly and legibly marked. When the heater is not energized, the control knob shall clearly indicate "off." The direction of turn for warmer air shall be marked on the controller. Verification of identification and marking features shall be in accordance with 4.3.6.13. Clarity of the identification information and markings shall not be degraded by temperature and humidity stress.

3.14 Workmanship. The heater shall be free from missing or loose parts; dented, cracked, or chipped surfaces; oil or foreign matter adhering to outside surface; and foreign matter blocking the air ports. Verification shall be in accordance with 4.2.2.1.

3.15 Color and Finish. The color of the exterior of the heater shall be white or off-white with gloss finish except for threads, controller knob, electrical connectors and plated parts. All external metallic surfaces or coatings applied to such surfaces shall resist corrosion, heat stress, and fungus. Verification shall be in accordance with 4.2.2.1 and 4.3.6.11.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

(a) First article inspection (see 4.2)
(b) Quality conformance inspection (see 4.3)

4.2 First article inspection

4.2.1 Sample. The first article sample shall consist of 24 heaters manufactured using the same methods, materials, equipment, and processes as will be used during regular production (see 6.2). Four (4) samples shall be allocated to each of the 6 inspection and test groups in table I. The first article sample shall be submitted for inspection and approval in accordance with the terms of the contract.

4.2.2 *Inspections to be performed.* As determined by the Government, the sample first article items may be subjected to any or all of the examinations and tests specified in this specification and be inspected for compliance with any or all of the requirements of the appli

TABLE I. First Article Inspection and Test

Group number	Requirement	Method
I	Maximum critical dimensions (3.2)	4.2.2.1
	Compatibility with interfacing parts (3.3)	4.2.2.1
	Controller operating features (3.4)	4.2.2.1
	Identification & markings (3.13)	4.3.6.13
	Workmanship (3.14)	4.2.2.1
II	Electromagnetic emissions (3.6)	4.2.2.2
	Compatibility with vehicle electrical system (3.11)	4.3.6.5
	Operability during movement (3.12)	4.3.6.6
	Performance (3.5)	4.3.6.1
III	Salt fog (3.9)	4.3.6.11
	Performance (3.5.3)	4.3.6.1
	Leakage (3.7)	4.3.6.2
	Color and finish (3.15)	4.2.2.1
IV	Temperature shock (3.9)	4.3.6.7
	Cold temperature operation (3.10)	4.3.6.4
	Humidity (3.9)	4.3.6.8
	Identification & marking (3.13)	4.3.6.13
	Performance (3.5.3)	4.3.6.1
V	Mechanical shock (3.9)	4.3.6.9
	Vibration (3.9)	4.3.6.10
	Operating life (3.8)	4.3.6.3
	Performance (3.5.3)	4.3.6.1
VI	Fungus (3.9)	4.3.6.12
	Performance (3.5.3)	4.3.6.1
	Color and finish (3.15)	4.2.2.1

cable drawings. Each heater in the first article lot shall be examined, functionally checked and tested in the sequence and in accordance with the test methods specified in table I.

4.2.2.1 Examination and functional checks. Verify that critical dimensions do not exceed maximum values specified in 3.2. Verify that the screw threads in the inlet and outlet ports and those in the heater for the attachment of the controller conform to the requirements in 3.3 by use of appropriate gages which conform to ASME B1.2 and B1.3M. Verify that all pairs of male and female electrical connectors external to the controller and heater may be pulled loose using ordinary hand force and reattached. Remove the controller from the heater and reattach it. Move the controller 45 degrees in either direction to the vertical plane that is perpendicular to the mounting bracket. Verify hole size and pattern of mounting bracket are as specified in 3.3. Verify that mounting holes in controller are located consistent with the requirements of 3.4. Visually examine items for compliance with workmanship requirements in 3.14 and color and finish requirements in 3.15.

4.2.2.2 Electromagnetic emissions. The heater shall, as a minimum, be tested for conductive and radiation emissions at minimum, mid-range and maximum controller settings using test apparatus and procedures described in Appendix A. The maximum allowable electromagnetic emission level for each test method and frequency is represented by the dependent variable "Y" in table II and illustrated in figures 1 through 5.

TABLE II. Electromagnetic Emission Upper Limits

Test Method 1/	Band Type	Frequency Range	Emission Upper Limits
CE01	Narrow	30 Hz to 400 Hz 400 Hz to 20000 Hz 2/	Y=120 4/ Y=−17.9 ln(F)+227
CE03	Narrow	0.02 to 2.0 MHz 3/ 2 to 50 MHz	Y=−6.51 ln(F)+24.5 5/ Y=20
CE03	Broad	0.02 to 2.0 MHz 2 to 50 MHz	Y=−16.3 ln(F)+61.3 6/ Y=50
RE02	Narrow	0.014 to 25 MHz 25 to 10000 MHz	Y=−2.00 ln(F)+26.5 7/ Y= 6.68 ln(F) −1.49
RE02	Broad	0.014 to 200 MHz 200 to 1000 MHz	Y=−4.70 ln(F)+79.9 8/ Y= 9.32 ln(F)+5.62

1/ See note 6.4 for references.

2/ Hertz (Hz)

3/ Mega (M)

4/ Y= decibels microampere, F = frequency, Hz

5/ Y= decibels microampere, F = frequency, MHz

6/ Y = decibels microampere/MHz, F = frequency, MHz

7/ Y = decibels microvolt/meter, F = frequency, MHz

8/ Y = decibels microvolt/meter/MHz, F = frequency, MHz

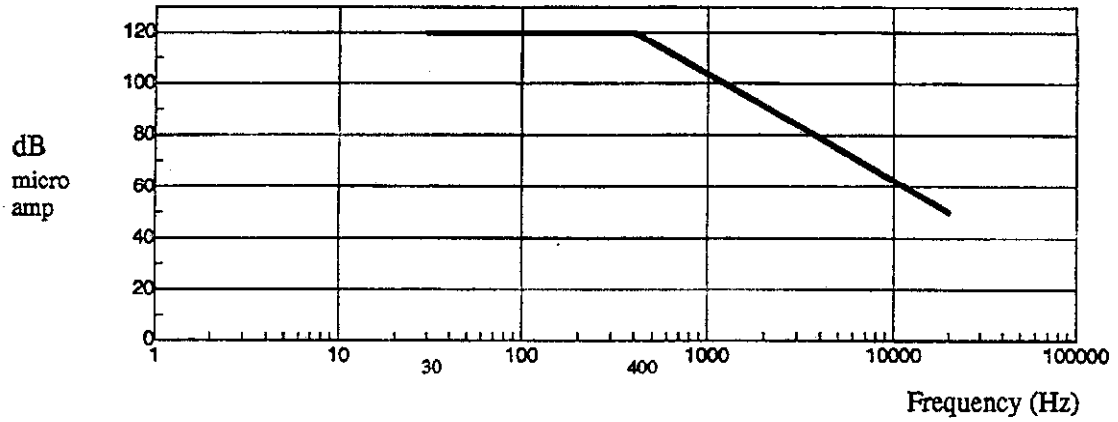


FIGURE 1. Upper limits for method CE01, narrowband emissions

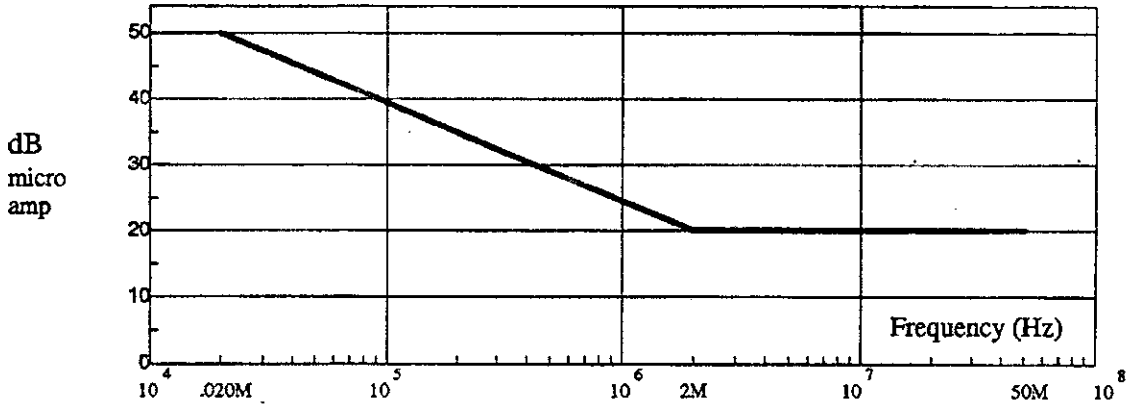


FIGURE 2. Upper limits for method CE03, narrowband emissions

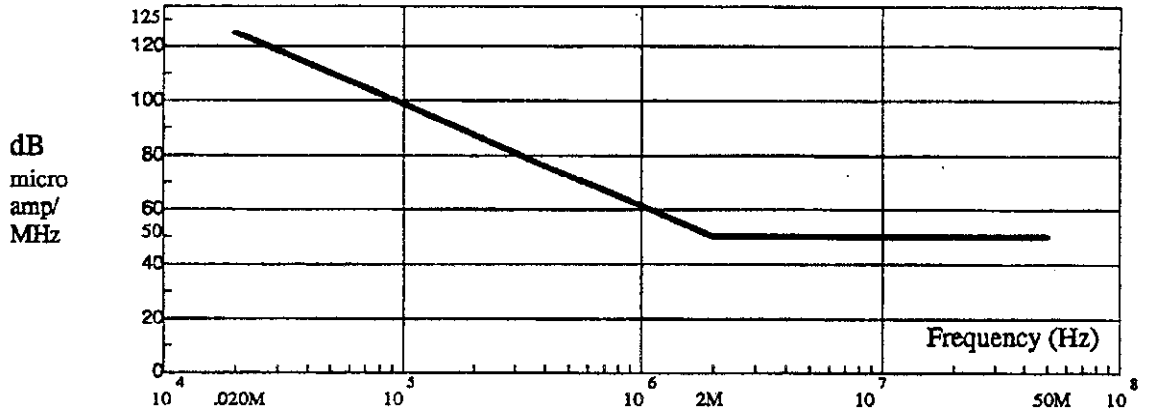


FIGURE 3. Upper limits for method CE03, broadband emissions

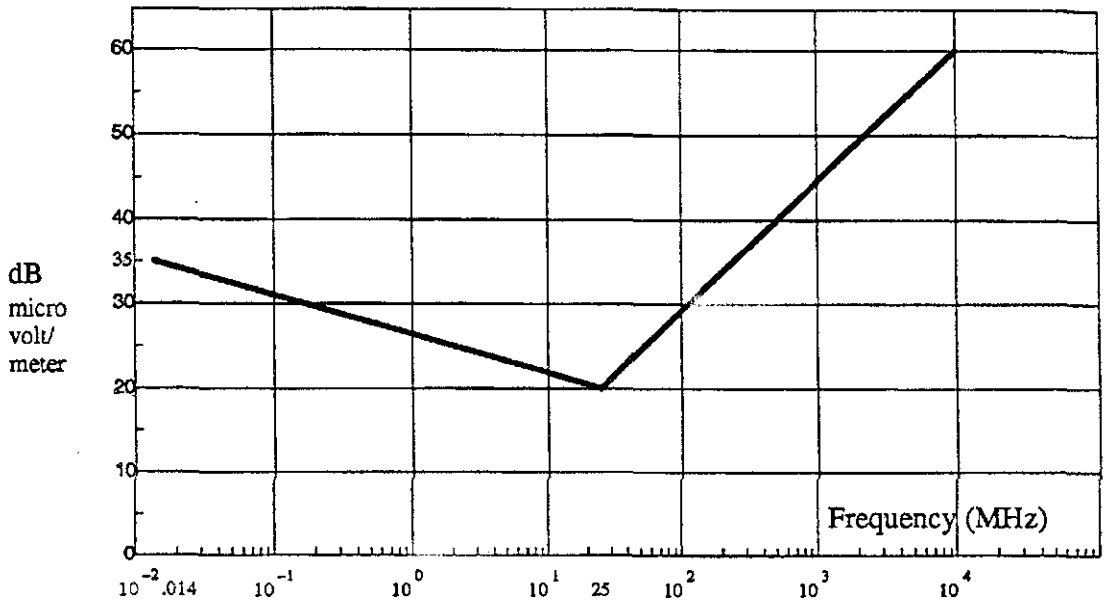


FIGURE 4. Upper limits for method RE02, narrowband emissions

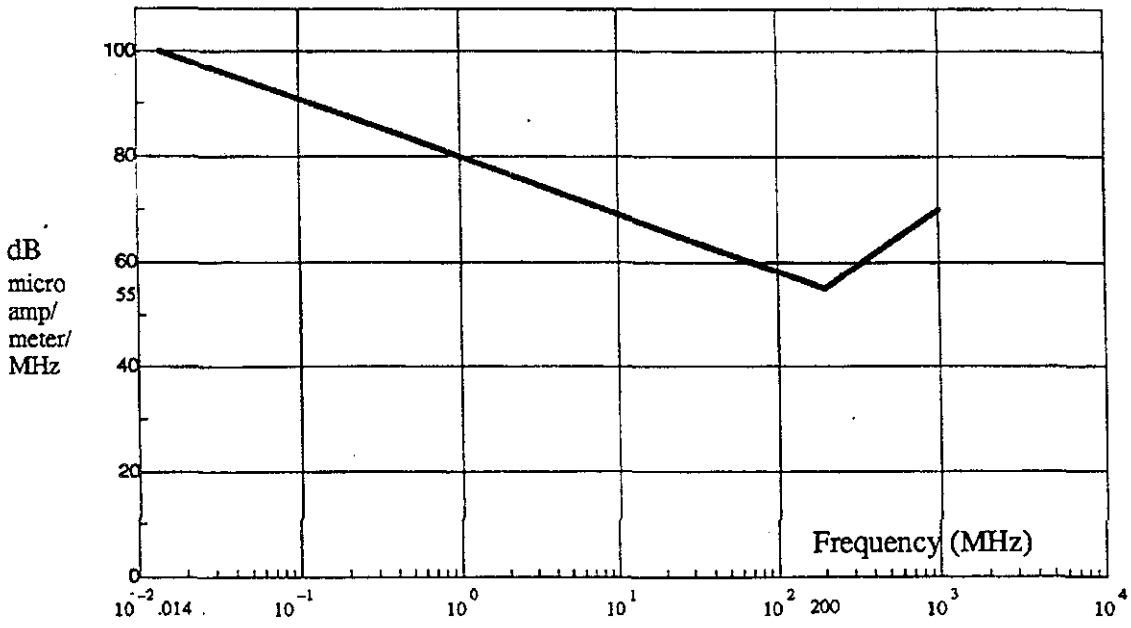


FIGURE 5. Upper limits for method RE02, broadband emissions

4.2.3 Acceptance criteria. If any first article sample item fails to comply with any of the applicable requirements, the first article sample shall be rejected. The Government reserves the right to terminate inspection upon any failure to comply with any of the requirements. The contractor shall obtain written approval from the contracting activity prior to proceeding with regular production.

4.3 Quality conformance inspection.

4.3.1 Lotting. A lot shall consist of the heaters produced by one manufacturer, at one plant, from the same materials, under the same manufacturing conditions. Each lot shall be identified by an alphanumeric lot number. The lot number shall include a manufacturer's identification symbol, a numeric code identifying the year of production, a code or abbreviation that signifies the month of production, and an interfix–serial number. The interfix–serial number shall change if there is change in the design, manufacturing process, materials, suppliers, production run, or if a new contract is issued.

4.3.2 Sampling. Sampling of lots shall be in accordance with classification of characteristics in 4.3.5, and when specified, table III. Samples shall be selected at random.

4.3.3 Inspection procedure. Sample items shall be examined and tested in accordance with the classification of characteristics in 4.3.5. Failure of any sample item to conform to any characteristic in the classification of characteristics based on the sampling and acceptance criteria specified therein shall be cause for rejection of the lot represented.

4.3.3.1 For examination. Samples shall be examined in accordance with the inspection methods identified in 4.3.5.

4.3.3.2 For test. Sample heaters shall be tested in accordance with inspection methods and test paragraphs referenced in 4.3.5.

TABLE III.

Lot size	Inspection levels and sample sizes										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
2 to 8	*	*	*	*	*	*	*	*	5	3	2
9 to 15	*	*	*	*	*	*	13	8	5	3	2
16 to 25	*	*	*	*	*	20	13	8	5	3	3
26 to 50	*	*	*	*	32	20	13	8	5	5	5
51 to 90	*	*	*	50	32	20	13	8	7	6	5
91 to 150	*	*	125	50	32	20	13	12	11	7	6
151 to 280	*	*	125	50	32	20	20	19	13	10	7
281 to 500	*	315	125	50	48	47	29	21	16	11	9
501 to 1200	*	315	125	75	73	47	34	27	19	15	11
1201 to 3200	1250	315	125	116	73	53	42	35	23	18	13
3201 to 10000	1250	315	192	116	86	68	50	38	29	22	15
10001 to 35000	1250	315	294	135	108	77	60	46	35	29	15
35001 to 150000	1250	490	294	170	123	96	74	56	40	29	15
150001 to 500000	1250	715	345	200	156	119	90	64	40	29	15
500001 and over	1250	715	435	244	189	143	102	64	40	29	15

*Indicates one hundred percent inspection. If sample size exceeds lot size, perform one hundred percent inspection.
Accept the lot represented on zero nonconforming characteristics and reject the lot represented on one or more nonconforming characteristics for all inspection levels.

4.3.4 Inspection characteristics. Critical characteristics are characteristics whose nonconformance to specified requirements is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product or whose nonconformance to specified requirements is likely to prevent performance of the tactical function of a major end item. Major characteristics are characteristics whose nonconformance to specified requirements is likely to result in failure or to reduce materially the usability of the item for its intended purpose. Minor characteristics are characteristics whose nonconformance to specified requirements is not likely to reduce materially the operation or usability of the item for its intended purpose.

4.3.5 Classification of characteristics. Conformance examinations and tests shall be as specified in the following classification of characteristics paragraphs. When specified herein, accept on 0 and reject on 1 attributes sampling inspection shall be performed on the designated characteristics using the stated levels in table III for selection of sample sizes.

CLASSIFICATION OF CHARACTERISTICS

PARAGRAPH	TITLE	SHEET 1 OF 1	DRAWING NUMBER
4.3.5	Heater, air, electric, filter unit, M3		NEXT HIGHER ASSY

CATEGORY	CHARACTERISTIC	SAMPLING	REQUIREMENT PARAGRAPH	INSPECTION METHOD
Critical	None defined			
Major				
101	Resistance to airflow	Table III, level IX	3.5.2	4.3.6.1(b)
102	Operability with thermostatic control	Table III, level IX	3.5.3	4.3.6.1(c)
103	Leakage	Table III, level IX	3.7	4.3.6.2
104	Mounting holes correct	Table III, level IX	3.3	CE & 4.2.2.1
105	Thread size of outlet and inlet openings correct	Table III, level IX	3.3	CE & 4.2.2.1
106	Electrical lead markers correct	Table III, level IX	3.13	VI
107	Inlet and outlet ports marked correct	Table III, level IX	3.13	VI
108	Markings for on/off status and temperature control correct	Table III, level IX	3.13	VI
109	Workmanship	Table III, level IX	3.14	VI
Minor	None defined			
201	Marking correct	Table III, level XI	3.13	VI
202	Color and finish	Table III, level XI	3.15	VI

NOTES:

CE – Commercial inspection equipment
VI – Visual inspection

4.3.6 Tests.

4.3.6.1 Performance.

(a) **Heating capability and power consumption.** Two calibrated thermocouples shall be installed in the system, one at the inlet and one at the outlet port, to measure the inlet and outlet air temperature. The thermocouples shall be installed approximately one inch from their respective ports. The heater shall be connected to a suitable power source capable of producing 27.5 volts direct current (vdc). A voltmeter and ammeter shall be connected to the electrical circuit. The heater shall be conditioned for 24 hours at 0±4°F prior to testing. Air, at 0±4°F and flowing at 4.5 cfm, shall pass through a calibrated gas metering device and then through the heater. Two of the 4 heater samples shall be tested with air flowing through the end inlet and outlet ports and the remaining two shall be tested with air flowing through the side inlet and outlet ports. Set the input voltage (voltage while operating) to 27.5 vdc. Rotate the control knob fully clockwise (full on), operate the heater continuously for at least 15 minutes, and record the current consumption during that period. After 15 minutes of operation, determine whether the power consumption and outlet air temperature meet the requirements in 3.5.1. (Note: turning the control knob fully clockwise for extended periods may result in outlet air temperatures that could be harmful to the hose and heater finish.)

(b) **Resistance to airflow.** The pressure differential shall be measured with a suitable manometer across the side inlet and outlet ports of the heater when the heater is receiving 4.5 cfm of air at ambient room temperature (70 ± 4°F) and not energized.

(c) **Operability with thermostatic control.** Two calibrated thermocouples shall be installed in the system, one at the side inlet port and one at the side outlet port, to measure the inlet and outlet air temperature. The thermocouples shall be installed within one inch from their respective ports. Six (6) additional calibrated thermocouples shall be attached to six scattered points, at least one of which shall be attached to the outlet boss, on the heater surface. With a voltmeter and ammeter connected to the electrical circuit, set the input voltage (voltage while operating) to 27.5 vdc . Ambient room air at 70± 4°F, flowing at 4.5 cfm, shall pass through a calibrated metering device and then through the heater. Turn the control knob fully clockwise until outlet air temperature rises to 120°F, then adjust knob until outlet air temperature stabilizes at 120±4°F. Maintain an outlet air temperature of 120 ± 4°F for a period of at least 5 minutes without adjustment of the controller knob. The heater is defective if it requires more than 10 minutes to attain the 120°F output temperature, or if it fails to maintain the output temperature within ± 4°F without adjustment of the controller knob. Compare the maximum measured case surface temperature against the specified value in 3.5.4. Repeat aforementioned test for an input voltage of 18.0 vdc and for an input voltage of 30.0 vdc (group II, first article samples only).

4.3.6.2 **Leakage.** With the side inlet and side outlet ports sealed with plugs, connect the end inlet port to a source of pressurized air with an airflow meter and appropriate regulating

valve(s) between the heater and pressurized air source (see Figure 6). Connect a manometer or pressure gage capable of measuring a static pressure of 12.0 inches of water gage (iwg) with an accuracy of ± 0.1 inches iwg to the end outlet port by means of appropriate adapters. The airflow meter shall be capable of measuring an airflow of 1.00 cubic inches per minute with an accuracy of ± 0.06 cubic inches per minute. Open the airflow and pressure regulating valve(s) and adjust the flow until a static pressure of at least 12 inches of water is established within the heater. The steady state flow rate that is required to maintain that pressure is the air leakage value. The heater is considered defective if the air leakage value exceeds the specified maximum value of 1.00 cubic inches per minute.

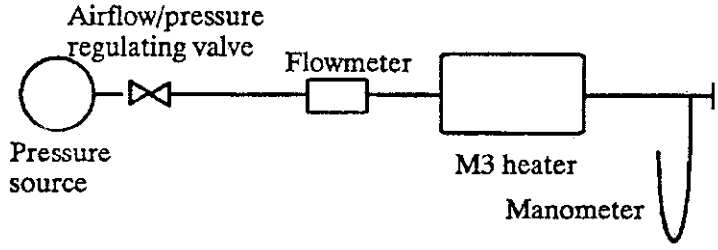


FIGURE 6. Leak test apparatus

4.3.6.3 Minimum operating life. A voltmeter and ammeter shall be connected to the electrical circuit. Ambient room temperature air shall be passed through a calibrated metering device through the heater, and exhausted outside the test area so that the heated exhaust will have no influence on the ambient room temperature. Input voltage shall be 27.5 vdc. At the start of the test, while the heater is operating at an airflow rate of 4.5 cfm , the controller shall be adjusted to an output air temperature of 120 ± 4°F. Aforementioned temperature shall be maintained for a minimum of 250 hours.

4.3.6.4 Cold temperature storage and operation. Place the heater in a chamber and condition it at −45° F for four hours. Operate the heater in this environment with the input voltage set to 27.5 vdc and the airflow set to 4.5 cfm, also at −45°F. Turn the control knob to the full "on" position and monitor the outlet air temperature until it attains 70 °F or until 15 minutes have elapsed. If the outlet air temperature rises to 70°F within 15 minutes, set the control knob to maintain this temperature within ± 4°F. Maintain an outlet temperature of 70 ± 4°F for a period of at least 5 minutes without adjustment of the controller knob. The heater is defective if it requires more than 15 minutes to attain the 70°F output temperature, or if it fails to maintain the output temperature within ± 4°F without adjustment of the controller knob.

4.3.6.5 Compatability with vehicle electrical system. The heater shall be tested with test equipment capable of measuring surge and spike voltages described herein. Operate the heater with the input voltage set to a nominal steady state voltage of 27.5 vdc. Apply a continuous 39 vdc surge voltage for 10 seconds to the power input terminals and determine whether the recovery time is less or equal to 0.015 sec. The recovery time is the interval between the time a voltage deviates from the steady state voltage limits (25 to 30 vdc) and the time it returns and remains within that same range. Then apply a 250 vdc spike voltage for 0.015 milliseconds.

4.3.6.6 Operability during movement. Rotate inlet and outlet ports 180 degrees to each side of the vertical position while the heater is energized by a 27.5 vdc source.

4.3.6.7 Temperature shock. While the heater is not in operation, subject it to the following sequence of temperature exposures.

(a) Place the test item in a high temperature chamber, and raise the chamber temperature to 160°F. Maintain for a period of not less than 4 hours or until the test item stabilizes.

(b) Transfer the test item, within 5 minutes, to a cold chamber with an internal temperature of −70°F. Maintain for a period of not less than 4 hours or until the test item stabilizes.

(c) Return the test item, within 5 minutes, to the high temperature chamber maintained at 160°F. Maintain for a period of not less than 4 hours or until test item stabilizes.

(d) Repeat steps (b) and (c) above.

(e) Repeat step (b) above.

(f) Test the heater in accordance with 4.3.6.4.

4.3.6.8 Humidity. While the heater is off, subject the heater to humidity stress as follows:

(a) Dry the test item at 129°F for 24 hours.

(b) Condition the test item at 73°F and 50 ± 10 percent relative humidity for 24 hours.

(c) Raise the internal chamber temperature to 86°F and the relative humidity to 94 ± 4 percent.

(d) Subject the test item to five continuous 48−hour cycles in accordance with figure 7.

(e) Condition the test item for 24 hours at 73°F and 50 ± 10 percent relative humidity.

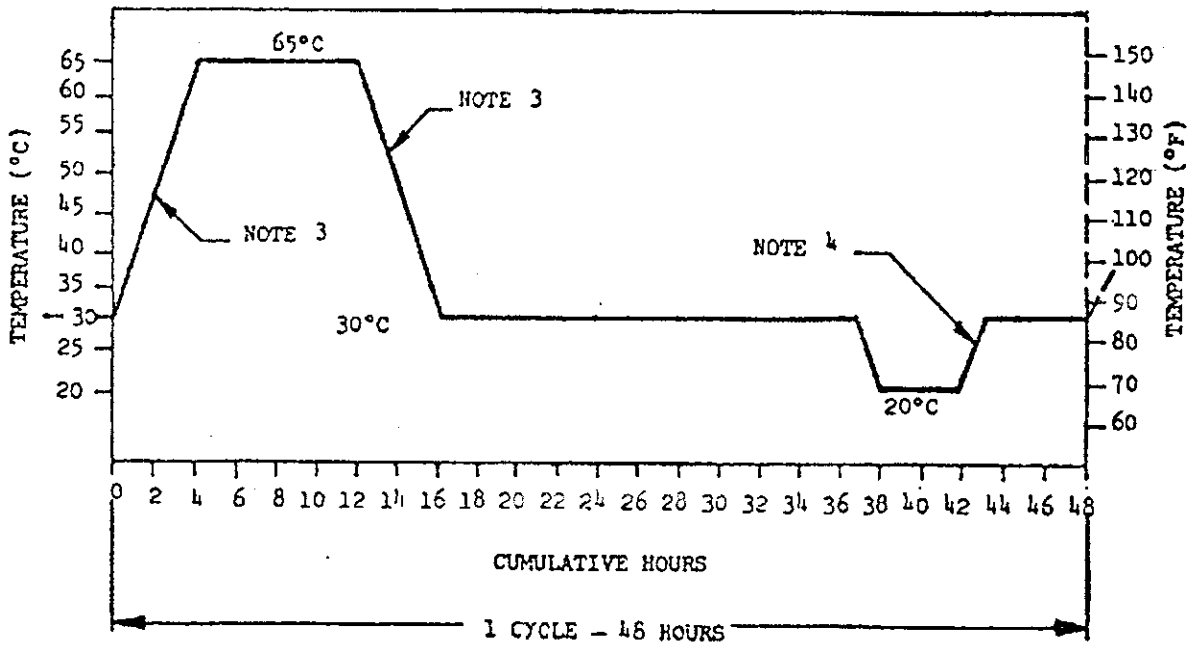


FIGURE 7. Temperature/humidity cycle

NOTES:

1. Tolerance during temperature change shall be not greater than 5°F.
2. Relative humidity shall be maintained at 94 ± 4 percent at all times, except that during the descending temperature period, the relative humidity may be permitted to drop as low as 85 percent.
3. Rate of temperature change between 86° and 149°F shall be not less than 14.4°F per hour.
4. The temperature increase in this portion of the curve shall be not less than 18°F.

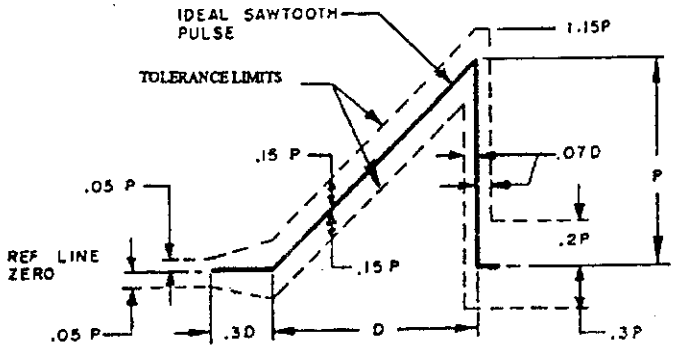
4.3.6.9 Mechanical shock. While the heater is "off", apply 3 shocks in each direction along three mutually perpendicular axes of the test item (total of 18 shocks). The shock pulse configuration shall conform to figure 8 on next page.

4.3.6.10 Vibration. Mount the heater onto a vibration exciter. While the heater is "off", subject the heater to sinusoidal vibration in each of three mutually perpendicular axes in accordance with table IV and curve W of figure 9 on next page. Test time per axis shall be 3 hours. The double amplitude displacements specified in table IV shall be maintained at the test item mounting points during the applied vibration. Sweep time of the applied vibration shall be 15 minutes over a logarithmic sweep frequency cycle of 5–500–5 hertz. If resonances below 5 hertz are measured or expected, the sweep time shall be 18 minutes over a sweep frequency cycle of 2–500–2 hertz. After vibration in each axis, check for loose or broken parts.

TABLE IV. Displacement versus frequency

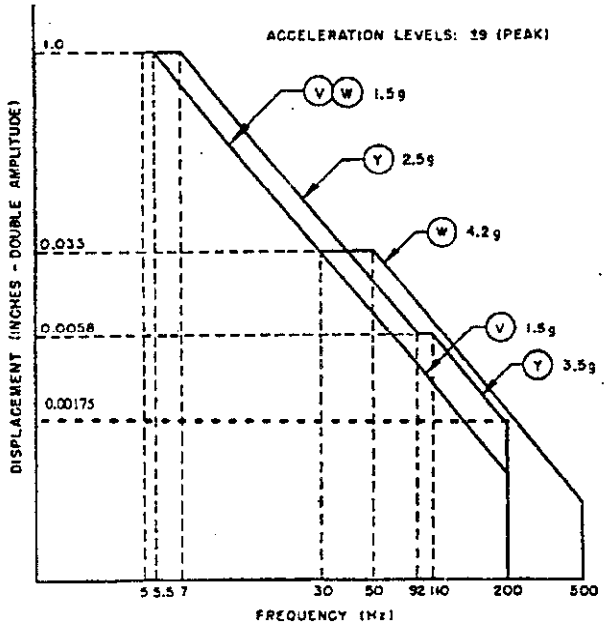
Displacement, D (inches–double amplitude)	Frequency, f (hertz)
1.0	2 to 5
$\ln(D) = -2.0 \ln(f) + 3.4$	5.5 to 30
0.033	30 to 50
$\ln(D) = -2.0 \ln(f) + 4.4$	50 to 500

4.3.6.11 Salt fog. The test chamber shall be equipped with supporting racks, temperature control in the exposure zone (note: do not use immersion heaters within the exposure zone), a salt solution reservoir, a means for injecting the salt solution into the chamber, and salt fog collection receptacles. Construction materials of aforementioned items shall be non–reactive to salt fog. While the heater is "off", place the heater in the test chamber and spray it with a continuously atomized, finely divided, wet, salt fog aerosol for a period of 48 hours. The aerosol shall be a mixture of 5% sodium chloride and 95% water by weight. Uniformly distribute the aerosol over the heater at a fallout rate between 0.20 ounce and 1.17 ounces (volume) of solution for each square foot of horizontal collecting area per hour during the 48–hour exposure at a constant 95°F with minimal air cirulation. (This fallout rate is equivalent to 0.625 to 3.75 ml/dm^2/hr, where 1 dm^2=100 cm^2.) The pH of the salt solution shall be maintained between 6.5 and 7.2. At the end of the exposure period, remove salt deposits with distilled water and dry the heater at ambient conditions for at least 48 hours. Inspect the heater for corrosion.



P = 30 g (g = 980.6 cm/S^2)
D = 11 milliseconds

FIGURE 8. Shock pulse configuration.



Note: All curves shall be extended to 2 Hz when test item resonances below 5 Hz are expected

(g = 980.6 cm/S^2)

FIGURE 9. Vibration test curves

4.3.6.12 Fungus. While the heater is "off", expose the heater to fungus in accordance with procedures in Appendix B.

4.3.6.13 Identification and marking. Verify that the heater's identification plate contains the required information. Verify that each of the items specified in 3.13 is marked clear and legible.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity. Note: except for interplant shipment, air heaters will normally be shipped with caps or covers which protect all inlet and outlet ports from foreign material.

6. NOTES

6.1 Intended use. The air heater covered by this specification is a component of the NBC GPFU systems utilized in various military vehicles, and is used to warm respiratory air supplied to individual protective masks and headpieces. Air from inside the vehicle is blown into a precleaner which contains a particulate filter and two gas filters before entering the heater.

6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number, and date of this specification.
(b) Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1).
(c) Packaging requirements (see 5.1).
(d) First article:

(1) Time allowed for contractor submission of samples for Government test and evaluation after award of contract when testing is performed by the Government.
(2) Name and address of test facility and shipping instructions when testing is performed by the Government.

(3) Time required for the Government to notify the contractor whether or not to proceed with production.

6.3 Safety. It is desired that the heater design comply with the safety requirements of UL 499 for internal wiring, electrical insulation, thermal insulation, and insulation resistance.

6.4 Electromagnetic emissions references. The technical basis for figures 1 through 5 and method CE01, CE03 and RE02 in this specification is MIL-STD-461A. The test set-up is based on MIL-STD-462.

6.5 Subject term (key word) listing.

Air heater
Electric heater
Filtered air
Gas Particulate Filter Unit (GPFU)
Respiratory air
Respiratory mask
Tank air heater
Temperature controller

6.6 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodian:

Army - EA

Preparing activity:

Army - EA

Project No. 4240-A241

APPENDIX A: ELECTROMAGNETIC EMISSION AND SUSCEPTIBILITY TESTS

A1. METHOD CE01 – CONDUCTED EMISSION, 30 HZ To 20 KHZ, POWER LEADS

A1.1 Purpose. This test method is used for measuring conducted emissions on d.c. power leads.

A1.2 Applicability. This test method is applicable for measuring conducted emissions in the frequency range of 30 Hz to 20 Khz on d .c. power input and output leads, including neutrals which are grounded externally to the equipment. Bonding straps do not have to be measured.

A1.3 Apparatus. The test apparatus shall include the following:

(a) Current probes.

(b) Matching transformer. – An impedance matching transformer may be needed between certain current probes and the interference meter so that the measuring system will meet the sensitivity requirements needed to perform the test.

(c) Electromagnetic interference (EMI) meter.

A1.4 Test Procedure. The test setup shall be as shown on Figure CE0l – l. The following equipment shall be used for narrowband measurements:

(a) Current probe

(b) Matching transformer

(c) Instrument with selectivity (interference meter)

A1.5 Notes:

(a) When matching transformers or band–reject filters are used, their characteristics must be described.

(b) Conducted emissions shall be measured separately on each power lead.

(c) The minimum separation between cables, leads and ground plan shall be 2 in. (5 cm).

(d) The length of power lead from the test sample to the feedthrough capacitor shall not exeed 1 meter.

(e) The length of each power lead between the point of separation and connection to the feedthrough capacitor shall be 30 $\pm$ 2 cm. The current probe shall be positioned along this length to produce a maximum reading on the EMI meter.

(f) For the case of EMI testing of the M3 heater, power source AC Phase I shown in Figure CE01–1 is not applicable. Ten microfarad capacitor connected to ground plane is optional for DC power source.

(g) The EMI measuring instrumentation shall be connected to the a.c power source through an isolation transformer. It is imperative that the chassis power ground be broken at this point to prevent the circulation of r .f . ground currents in the test equipment.

(h) Be sure all test instrumentation is properly bonded to the ground plane before applying power to prevent a potential shock hazard to personnel.

1. 5 cm Standoffs
2. Low Impedance Bond to Ground Plane
3. Current Probe
4. Test Sample Chassis Ground
5. High Side
6. Return
7. DC bond impedance between the ground plane and enclosure shall not exceed 2.5 milliohms.

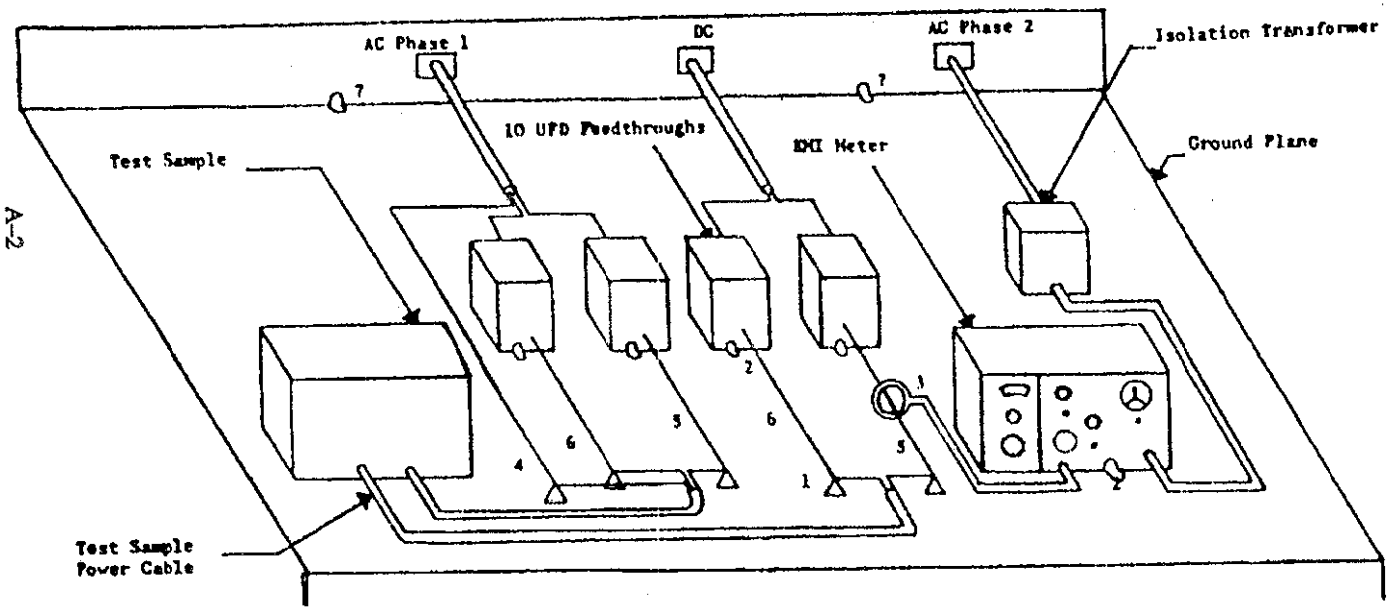


Figure CE01-1 - Typical current probe test setup for conducted emission measurements on power leads (cont'd).

A2. METHOD CE03 – CONDUCTED EMISSION, 20 KHZ To 50 MHZ, POWER LEADS

A2.1 Purpose. This test method is used for measuring conducted emissions on all power leads.

A2.2 Applicability. This test method is applicable for measuring conducted emissions in the frequency range of 20 KHz to 50 MHz on d.c. power input and output leads, including neutrals which are grounded externally to the equipment. Bonding straps do not have to be measured.

A2.3 Apparatus. The test apparatus shall include the following:

(a) Current probes

(b) Electromagnetic interference meter

A2.4. Test Procedure. The test setup shall be as shown on Figure CE01 – 1. Conducted emissions shall be measured separately on each power lead.

A3. METHOD RE02 – RADIATED EMISSION, 14 KHz, TO 10 GHz, ELECTRIC FIELD

A3.1. Purpose. This method is used for measuring radiated electromagnetic emissions from the heater system including the controller.

A.3.2 Applicable Frequency Range for Test

(a) Narrowband emissions shall be measured from 14 KHz, to 10 times the highest used or intentionally generated frequency, or 1 GHz, whichever is greater; however, the measured frequency shall not exceed 10 GHz.

(b) Broadband emissions shall be measured from 14 KHz to 1 GHz.

A3.3. Apparatus. Test apparatus shall consist of the following:

(a) Test antennas.

(b) EMI Meters

A3.4. Test Set–Up and Procedure.

A3.4.1 Test Setup. The basic test set–up is shown in Figure RE02–1.

A3.4.2 Procedure. The test procedures is as follows:

(a) Probe the test sample to locate the points of maximum radiation from the test sample.

(b) Select and position the test antennas. In the frequency range of 25 to 200 MHz, position the test antennae so as to make both vertical and horizontal measurements.

(c) For each test antenna, scan the applicable frequency range of this test with the EMI meter and take measurements as required.

(f) For the case of DC power source, the use of ten microfarad capacitors connected to ground plane in figure RE02–1 is optional.

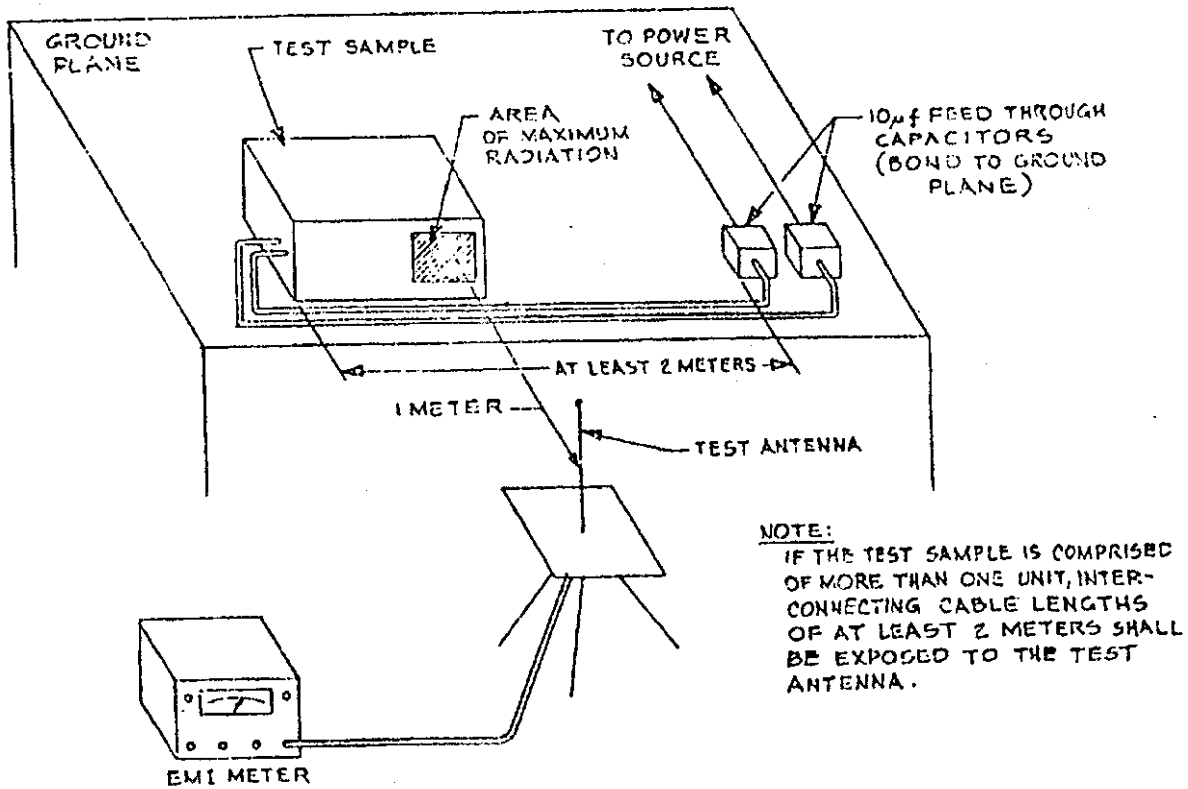


Figure RE02-1 - Typical test setup for radiated measurements

APPENDIX B: FUNGUS TEST PROCEDURES

B.1 SCOPE. This appendix details the procedure for conducting fungus resistance verification. This appendix is a mandatory part of this specification.

B.2 PROCEDURE

B.2.1 Mineral salts preparation. Using clean apparatus, prepare a mineral salts solution containing the following, then verify the pH of the mineral salts solution is between 6.0 and 6.5.

Potassiuim dihydrogen orthophosphate (KH_2PO_4)	0.700 g
Potassiuim monohydrogen orthophosphate (K_2HPO_4)	0.700 g
Magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$)	0.700 g
Ammonium nitrate (NH_4NO_3)	1.000 g
Sodium chloride (NaCl)	0.005 g
Ferrous sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$)	0.002 g
Zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$)	0.002 g
Manganous sulfate monohydrate ($MnSO_4 \cdot H_2O$)	0.001 g
Distilled water	1000 ml

B.2.2 Spore preparation. Prepare a spore suspension using aseptic techniques containing at least the test fungi, listed in table B-I. Distribution of fungi in a lyophilized state or on agar slants is acceptable.

Table B-I. Test Fungi

Fungi	Fungus Sources Identification No.	
	DSPA[1]/	ATCC[2]/
Aspergillus niger	GM 386	ATCC 9842
Aspergillus flavus	GM 380	ATCC 9643
Aspergillus versicolor	GM 432	ATCC 11730
Penicillium funiculogum	GM 474	ATCC 11797
Chaetomium globogum	GM 459	ATCC 6205

1/ US Department of Agriculture (SEA/FR)
Northern Regional Research Center
ABS Culture Collection
1815 North University Street
Peoria, Illinois 60604

2/ American Type Culture Collection
12301 Parklawn Drive
Rockville, Maryland 20852

B.2.2.1 Spore Storage. Maintain pure fungus cultures separately on an appropriate medium such as potato dextrose agar. Culture Chaetomium globosum on strips of filter paper overlaid on the surface of mineral salts agar. Prepare mineral salts agar by dissolving 15.0 g of agar in a liter of mineral salts solution. Store the stock cultures for more than four months at 43 ± 7° F. After that time, prepare subcultures and use them for the new stocks. Verify culture purity before the fungus resistance test.

B.2.2.2 Stock cultures preparation. Incubate subcultures used for preparing new stock cultures or the spore suspension at 86 ± 2.5° F for 14 to 21 days. Then prepare a spore suspension of each fungus by pour-

ing 10 ml of an aqueous solution containing 0.05 g per liter of a non–toxic wetting agent such as sodium dioctyl sulfosuccinate or sodium lauryl sulfate into one subculture of each fungus.

B.2.2.2.1 Stock cultures separation. Use a rounded glass rod to gently scrub the surface growth from the culture of the test organisms. Pour the spore charge into a 125 ml capped Erlenmeyer flask containing 45 ml of water and 50 to 75 solid glass beads, 5 mm in diameter. Shake the flask vigorously to liberate the spores from the fruiting bodies and to break the spore clumps. Filter the dispersed fungal spore suspension into a flask through a 6 mm layer of glass wool contained in a glass funnel. This process should remove large mycelial fragments and clumps of agar.

B.2.2.2.2 Stock cultures solution. Centrifuge the filtered spore suspension and discard the supernatant liquid. Resuspend the residue in 50 ml of water and recentrifuge. Wash the spores obtained from each fungus three times in this manner. Dilute the final washed residue with mineral–salts solution so the resultant spore suspension contains 1,000,000 ± 200,000 spores per milliliter, determined with a counting chamber. Repeat this operation for each organism used in the test..

B.2.2.2.3 Spore viability test. Before preparing the composite spore suspension, inoculate sterile potato dextrose agar plates with 0.2 to 0.3 ml of the spore suspension of each of the individual fungi. Distribute the inoculum over the entire surface of the plate. Continue with the remainder of the fungus test while the viability test is underway. After 7 to 10 days at 75° to 88° F, check the viability test plates for fungal growth. Absence of copious growth of any of the test organisms over the entire surface in each container invalidates the results of any tests using these spores.

B.2.2.3 Fungus test suspension. Blend equal volumes of the five stock culture solutions to obtain the final mixed spore suspension. The suspension storage limits are seven days at 43 ± 7°F.

B.2.3 Fungus resistance test. Prepare the following solution:

Glycerol	10.0 g
Potassiuim dihydrogen orthophosphate (KH_2PO_4)	0.100 g
Ammonium nitrate (NH_4NO_3)	0.100 g
Magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$)	0.025 g
Yeast extract	0.050 g
Non–toxic wetting agent (e.g. sodium dioctyl sulfosuccinate or sodium lauryl sulfate)	0.005 g
Distilled water (total volume)	100 ml
Final solution pH using HCl and NaOH	5.3

Dip sterile 100% cotton strips into the solution. After dipping, remove excess liquid and hang to dry. Place the control strips vertically close to and bracketing the test article so the control strips and test article experience the same test chamber environment. Ensure the strips are long enough to be at the same height as the test article. These strips verify conditions to promote fungal growth in the chamber.

B.2.3.1 Test article preparation. Verify the test article is similar to the condition delivered by the manufacturer. Do not clean the test sample for at least 72 hours before the test. Install the test article in the chamber or cabinet on suitable fixtures or suspended from hangers. Hold the test item in the operating chamber at 77.5 ± 2.5 °F and 95 ± 5% relative humidity for at least four hours immediately before inoculation.

B.2.3.2 Test article inoculation. Inoculate the test article and the cotton fabric control strips with the mixed fungal spore suspension by spraying the suspension on the control strips and on (and into) the test article in a fine mist from an atomizer or nebulizer. Personnel with knowledge of the test article should aid in exposing its interior surfaces for inoculation. When spraying, take care to cover all external and internal surfaces normally exposed during use or maintenance. If the surfaces are non–wetting, spray until drops

begin to form. Replace any test article covers without tightening the fasteners so that air can penetrate. Start incubation immediately following the inculation.

B.2.3.3 Test article incubation. Incubate the test article under a daily cycle of temperature and humidity conditions for 20 hours at a relative humidity of 95 ± 5% and air temperature of 86 ± 2°F. Follow with a 4–hour lower temperature period. Use up to two hours of the 4–hour period to transition the temperature and relative humidity. During the transition period, keep temperature and humidity conditions between 75° to 88°F and relative humidity above 90%. Conditions during the remaining portion of the lower temperature period shall be 77 ± 2°F temperature and 95% (+5%, –0%) relative humidity.

B.2.3.4 Test duration. Repeat the 24–hour daily cycle in B.2.3.3 for 28 days of incubation from the time of inoculation. After seven days of incubation, inspect growth on the control cotton strips. Verify that fungi covers at least 50% of the part of the surface area of each test strip located at the level of the test article. If not, repeat the entire test with the adjustments of the chamber required to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test. If there is a decrease in fungal growth on the cotton strips at the end of the test compared to the 7–day results, the test is invalid.

B.2.4 Inspection criteria. At the end of the incubation period, inspect the test article immediately. If possible, inspect the item inside the chamber. If the inspection is outside the chamber and not completed in eight hours, return the test article to the test chamber or similar humid environment for at least 12 hours. Examine all surfaces of the test article. Intermittent infestations or loosely spread microbial colonies on the surface and moderate reproduction is permissible.